FORM PTO-1390 (Modified) (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	
Berge-1	
U.S. APPLICATION NO (IF KNOWN, SEE 37 CFR)	
09/529193	
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE
PCT/FR98/02143	October 7, 1998
PRIORITY DATE CLAIMED	
October 8, 1997	

TITLE OF INVENTION
VARIABLE FOCUS LENS

APR 05 2000

APR 06 2000

APPLICANT(S) FOR DO/EO/US
BERGE, Bruno; PESEUX, Jerome

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409)
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Date-stamped receipt card

U.S. APPLICATION NO (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
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21. The following fees are submitted:

	CALCULATIONS PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :	
☒ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO $970.00	
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO $840.00	
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $690.00	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $670.00	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $96.00	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$970.00
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	$0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	10 - 20 =	0	x $18.00	$0.00
Independent claims	1 - 3 =	0	x $78.00	$0.00
Multiple Dependent Claims **(check if applicable)**.			☐	$0.00
TOTAL OF ABOVE CALCULATIONS			=	$970.00
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable)**.			☐	$0.00
SUBTOTAL			=	$970.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).			+	$0.00
TOTAL NATIONAL FEE			=	$970.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).**			☐	$0.00
TOTAL FEES ENCLOSED			=	$970.00
			Amount to be: refunded	$
			charged	$

☒ A check in the amount of **$970.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **50-1057** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

Arthur L. Plevy
NAME

24,277
REGISTRATION NUMBER

4/6/2000
DATE

Attorney Docket No.

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9 (f) and 1.27 (c)) -- SMALL BUSINESS CONCERN

I hereby declare that I am

[ ] the owner of the small business concern identified below
[X] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN UNIVERSITE JOSEPH FOURIER

ADDRESS OF CONCERN 621, Avenue Centrale, B.P. 53, 38041 GRENOBLE CEDEX 9, FRANCE

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under section 41 (a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled VARIABLE FOCUS LENS
by inventor(s) BERGE Bruno, PESEUX Jérôme
described in

[ ] the specification filed herewith
[X] Application Serial No. 09/529 193, filed 6 APRIL 2000.
[ ] Patent No. _____, issued _____.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

***NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)**

FULL NAME UNIVERSITE JOSEPH FOURIER

ADDRESS SAME AS ABOVE

[ ] Individual [ ] Small Business Concern [X] Nonprofit Organization

FULL NAME _____

ADDRESS _____

[ ] Individual [ ] Small Business Concern [ ] Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Claude FEUERSTEIN

TITLE OF PERSON OTHER THAN OWNER President

ADDRESS OF PERSON SIGNING UNIVERSITE JOSEPH FOURIER
621, Avenue Centrale, B.P. 53, 38041 GRENOBLE CEDEX 9, FRANCE

SIGNATURE _____ DATE 22-5-2000

for President of UNIVERSITE
Joseph FOURIER - Grenoble 1

Claude FEUERSTEIN

VARIABLE FOCUS LENS

The present invention relates to the field of variable focal lenses, and more specifically to liquid lenses having a variable electrically controlled focus.

An article of B. Berge entitled "Electrocapillarité et mouillage de films isolants par l'eau" published in 1993 in C.R. Acad. Sci. Paris, t. 317, serial II, pages 157 to 163, discloses a device comprising a drop of conductor liquid placed on a dielectric film covering a flat electrode. A voltage may be applied between the liquid conductor drop and the electrode. This article describes a theoretical study of the wetting variation of a dielectric material with respect to a conductor liquid and shows that the wetting increases substantially in presence of an electric field caused by the voltage existing between the conductor liquid and the electrode. This phenomenon is called electrowetting by the author.

U.S. Patent N° 5,659,330 discloses a display device using the electrowetting phenomenon to vary the shape of a drop of opaque conductor liquid placed on a dielectric. This document does not suggest the use as an optic lens.

An article of Vallet, Berge and Vovelle, "Electrowetting of water and aqueous solutions on poly(ethylene terephthalate) insulating films", published in Polymer, Vol. 37, N° 12, pages 2465 to 2470, 1996, discloses a deformation of

a liquid conductor drop to which a voltage is applied. It is indicated that, when the applied voltage becomes too high, the surface of the drop becomes unstable, and microdroplets may be ejected at the periphery of the drop.

This makes prior art systems inadequate for forming variable lenses. Moreover, these systems need a transparent biasing electrode and a connection for the electrode, which makes the system difficult to manufacture or inefficient.

An object of the present invention is to provide a lens whose focus may vary continuously as a function of an electric control, by using the phenomenon of electrowetting.

Another object of the present invention is to provide a lens which is simple to manufacture.

Another object of the present invention is to provide a lens which is simple to use.

For achieving these objects, the present invention provides a variable focus lens comprising a chamber filled with a first liquid, a drop of a second liquid being disposed at rest on a region of a first surface of an insulating wall of the chamber, the first and second liquids being non miscible, of different optical indexes and of substantially same density. The first liquid is conductive and the second liquid is insulating. The lens further comprises means for applying a voltage between the conductor liquid and an electrode placed on the second surface of said wall; and centering means for maintaining the centering of the edge of the drop while the voltage is applied and for controlling the shape thereof.

According to an embodiment of the invention, the centering means allows a continuous maintaining of the centering of the drop and a continuous control of the shape of the edge of the drop while a varying voltage is applied by said means for applying a voltage.

According to an embodiment of the invention, the first surface is substantially flat, the contact region is

circular and centered about an axis which is perpendicular to the first surface.

According to an embodiment of the invention, the centering means corresponds to a progressive thickening of the second surface of the wall of the chamber towards said axis, said electrode being applied against said second surface.

According to an embodiment of the invention, the centering means corresponds to a radial decrease of the wetting with respect to the first liquid, towards the center of said contact region with the second liquid.

According to an embodiment of the invention, the centering means corresponds to a radial gradient of the dielectric constant of said wall of the chamber at the level of said contact region with the second liquid.

According to an embodiment of the invention, the first surface is substantially flat, the contact region 15 is circular and centered about an axis perpendicular to the first surface, and the centering means comprises an electrode formed of one or several circular concentric strips insulated from each other, centered about said axis, the circular strips being supplied by distinct voltage sources of values decreasing towards said axis.

According to an embodiment of the invention, the chamber is cylindrical, the first surface is the internal surface of the chamber, the contact region with the second liquid corresponds to a cylindrical section of the chamber, the centering means is comprised of one or several cylindrical electrodes of same diameter, insulated from each other, placed side by side against the external surface of the chamber at the level of the border of said contact region, the electrodes being supplied by different voltages of values decreasing towards the center of said contact region.

According to an embodiment of the invention, the first surface is substantially flat, the contact region is rectangular and symmetric with respect to an axis perpendicular

to the first surface and the centering means is comprised of an electrode formed of one or several rectangular concentric strips insulated from each other, symmetric with respect to said axis, the rectangular strips being supplied by distinct voltage sources of decreasing values towards said axis.

According to an embodiment of the invention, said wall is comprised of two non parallel planes and in which said region bridges said two planes.

The foregoing and other objects, features, aspects and advantages of the invention will become apparent from the following detailed description of embodiments, given by way of illustration and not of limitation with reference to the accompanying drawings:

Figure 1 shows a first embodiment of a variable focus lens according to the present invention;

Figure 2 shows a second embodiment of a variable focus lens according to the present invention;

Figure 3 shows a third embodiment of a variable focus lens according to the present invention;

Figure 4 shows a fourth embodiment of a variable focus lens according to the present invention;

Figure 5 shows a fifth embodiment of a variable focus lens according to the present invention; and

Figure 6 shows another embodiment of a variable focus lens according to the present invention.

Figure 1 shows a simplified cross-section view of a variable focus liquid lens according to a first embodiment of the present invention. A drop of an insulating liquid 11 is located on the internal surface of a wall of a dielectric chamber 12 filled with a conductor liquid 13. The insulating liquid 11 and the conductor liquid 13 are both transparent, not miscible, have different optical indexes and have substantially the same density. The dielectric 12 naturally has a low wetting with respect to the conductor liquid 13. A surface treatment 14 insuring a high wetting of the wall of the dielectric chamber

with respect to the conductor liquid 13 surrounds the contact region 15 between the insulating liquid drop 11 and the wall of chamber 12. The surface treatment 14 maintains the positioning of drop 11, preventing the insulating liquid from spreading beyond the desired contact surface. When the system is at rest, the insulating liquid drop 11 naturally takes the shape designated by reference A. "O" designates the axis which is perpendicular to the contact region 15 and passing through the center of contact region 15. At rest, the insulating liquid drop 11 is centered about axis O which constitutes the optical axis of the device. The elements of the device which are adjacent to axis O are transparent. An electrode 16, letting through light in the vicinity of axis O, is placed on the external surface of the wall of dielectric chamber 12, on which is situated the insulating liquid drop 11. An electrode 17 contacts the conductor liquid 13. Electrode 17 may be immersed in liquid 13, or be a conductor deposition achieved on an internal wall of chamber 12.

When a voltage V is established between electrodes 16 and 17, an electrical field is created which, according to the above mentioned electrowetting principle, will increase the wetting of region 15 with respect to conductor liquid 13. As a consequence, conductor liquid 13 moves and deforms the insulating liquid drop 11. A variation of the focus of the lens is thus obtained.

However, the center of the drop is likely to move with respect to axis O during the deformation. Moreover, the outline of the contact surface is likely to lose its circular character during the deformation of the drop. An aspect of the present invention is to maintain the circularity of the drop and its concentricity with respect to axis O while its shape changes by generating an electric field which decreases radially towards the center of region 15.

For avoiding this, according to an aspect of the present invention, a centering means for drop 11 is additionally

provided. Examples of such centering means appear in the second to sixth embodiments of the invention described hereinafter.

Figure 2 shows a simplified cross-section view of a variable focus liquid lens according to a second embodiment of the present invention. Elements such as drop 11, axis O, chamber 12, conductor liquid 13, surface treatment 14, contact region 15 and electrode 17 are the same as those of the embodiment illustrated in figure 1. The positions A and B also correspond to the rest position of drop 11 and to the limit position of drop 11, respectively. In this second embodiment, the centering means comprises the generation of an electrical field which decreases radially towards the center of region 15. For this purpose, an electrode 26 is provided which has a surface which progressively departs from the surface of region 15 while approaching axis O. Such an electrode 26 may, for example, be obtained by depositing a metallic film on the lateral walls of a taper centered about axis O, achieved on the external surface of the wall of chamber 12 on which is placed drop 11. An alternative embodiment may consist in depositing a metallic film on the surface of a transparent dielectric resin drop centered about axis O, attached to the external surface of the wall of chamber 12 on which drop 11 is placed. The top of the resin drop is planed in the vicinity of axis O to let the light through.

One may increase voltage V from 0 volt to a maximum voltage which depends on the used materials. When the maximum voltage is reached, the insulating liquid drop 11 reaches a limit position (designated by reference B). When voltage V varies continuously between 0 volt and its maximum value, the insulating liquid drop 11 continuously deforms from position A to position B. It will be noted that, drop 11 being of an insulating liquid, no microdroplets are produced at its periphery when the voltage is high, in contrast to what would happen if the drop was of a conductor liquid (see the above mentioned article of Vallet, Berge and Vovelle).

Figure 3 shows a simplified cross-section view of a variable focus liquid lens according to a third embodiment of the present invention. Elements such as drop 11, axis O, chamber 12, conductor liquid 13, surface treatment 14, contact region 15 and electrode 17 are the same as those of the embodiment described in figure 1. The positions A and B also correspond to the rest position of drop 11 and to the limit position of drop 11, respectively.

In this third embodiment, on the external surface of the wall of chamber 12 is placed a group of three circular concentric electrodes, 35, 36 and 37, insulated from each other, and having O as axis. A voltage may be applied between each of electrodes 35, 36 and 37 and electrode 17; exemplary voltages V1, V2 and V3 are shown, each of which may vary. The voltages are chosen at any time with decreasing values towards axis O so that the electric field generated by applying the voltages to electrodes 35, 36 and 37 decreases radially towards the center of region 15. When voltages V1, V2 and V3 continuously vary between 0 volt and their maximum value, the insulating liquid drop 11 deforms continuously between its rest position A and its limit position B.

According to an alternative of this third embodiment, each electrode 35, 36 and 37 may be connected by a switch, either to a same voltage source V, either to ground. For a constant voltage V, the shape of drop 11 is then varied by varying the number of electrodes to which a voltage is applied. In this case, the focus variation is discrete and not continuous. Only certain predetermined focuses can thus be obtained for the lens comprised of drop 11, but the benefit is then that the voltage control is relatively simple to implement.

Figure 4 shows a simplified cross-section view of a variable focus liquid lens according to a fourth embodiment of the present invention. Elements such as drop 11, axis O, conductor liquid 13, surface treatment 14, contact region 15 and electrodes 16 and 17 are the same as those of the embodi-

ment described in figure 1. The positions A and B also correspond to the rest position of drop 11 and to the limit position of drop 11, respectively.

In this fourth embodiment, the wall of the dielectric chamber 52 on which the insulating liquid drop 11 is placed, comprises a circular dielectric region 53, letting through the light about axis O. Region 53 has a low wetting with respect to conductor liquid 13 in the absence of a surface treatment 14. Region 53 has been treated in such a way that its dielectric constant varies radially and continuously towards axis O, and that the electric field generated by voltage V has a gradient which decreases radially towards axis O on the contact region 15. When voltage V is varied continuously between 0 volt and its maximum value, the insulating liquid drop 11 continuously deforms between its rest position A and its limit position B.

Figure 5 shows a simplified cross-section view of a variable focus liquid lens according to a fifth embodiment of the present invention. Elements such as drop 11, axis O, dielectric chamber 12, conductor liquid 13, contact region 15 and electrodes 16 and 17 are the same as those of the embodiment described in figure 1. The positions A and B also correspond to the rest position of drop 11 and to the limit position of drop 11, respectively.

In this fifth embodiment, the surface of the wall of dielectric chamber 12 on which the insulating liquid drop 11 is placed has been treated at different regions 14, 65, 66 and 67 such that the wetting of regions 14, 65, 66 and 67 with respect to conductor liquid 13 decreases radially towards axis O. A voltage V may be applied between electrode 16 and electrode 17. The electric field generated by voltage V increases the wetting of regions 14, 65, 66 and 67 but maintains the initial wetting gradient. When voltage V varies between 0 volt and its maximum value, the shape of the insulating liquid drop 11 continuously varies between its rest position A and its limit position B.

Figure 6 shows a simplified cross-section view of another embodiment of the present invention in which an insulating liquid 11 occupies the bottom portion of a cylindrical dielectric chamber and is covered by a conductor liquid 13. The chamber is designated by reference 12. The materials composing elements 11, 12 and 13 are the same as those of the previous embodiments.

A surface treatment 14 insuring a high wetting of the internal wall of chamber 12 with respect to the conductor liquid 13 is achieved above the contact region 15 between liquid 11 and the internal surface of chamber 12. The surface treatment 14 allows the position of liquid 11 to be maintained for avoiding this liquid from spreading beyond the contact surface. For simplifying the description only the top portion of liquid 11 will be considered and it will be called, like in the previous embodiment, "drop 11". When the system is at rest, the insulating liquid drop 11 naturally takes the shape designated by reference A. Axis O is the axis of chamber 12. At rest, the insulating liquid drop 11 is centered about axis O which constitutes the optical axis of the device. Several electrodes 75, 76, 77, 78, 79 are placed about the external wall of dielectric chamber 12 in the vicinity of contact region 15. The electrodes 75, 76, 77, 78, 79 are insulated from each other and a voltage V is established between electrode 75 and an electrode 17 contacting the conductor liquid 13. The electrodes 76, 77, 78, 79 are biased through capacitive influence when voltage V is established. At wall 12, the electric field generated by voltage V decreases according to a longitudinal gradient from electrode 75 towards electrode 79. When voltage V increases, conductor liquid 13 moves and deforms the insulating liquid drop 11. A variation of the focus of the lens is thus obtained. The above-mentioned electric field gradient insures that the drop permanently has a radial symmetry with respect to axis O. When voltage V varies between 0 volt and its maximum

value, the insulating liquid drop 11 varies continuously between its rest position A and its limit position B.

Those skilled in the art will be able to combine the features appearing in the various embodiments of the invention described above.

Moreover, the present invention may be subject to various alternatives which will appear to those skilled in the art.

The surface of the dielectric chamber 12 of figure 1 may be concave or convex, in order to obtain a particular diopter value of the device at rest.

The contact region between the insulating liquid drop and the dielectric chamber may be treated for having a high wetting with respect to the insulating liquid, in order to simplify the positioning of the insulating liquid drop.

In the case of a dielectric chamber naturally having a high wetting with respect to the conductor liquid, the contact region may be achieved by a surface treatment adapted to providing it with a low wetting with respect to the conductor liquid.

The surface treatment 14 may consist of depositing or sticking a film of a material having a high wetting with respect to conductor liquid 13.

Electrode 16 of figure 1 may be replaced with a conductor liquid in contact with the external surface of chamber 12, voltage V then being established between this conductor liquid and liquid 13.

It will be possible to realize a device including an array formed of groups of three, separately controlled, variable focus lenses, colored in red, green, and blue, operating, for example, in a binary mode, stopping or allowing through light originating from a unique source of white light, thus forming a luminous color screen which may be of big size and of moderate cost.

It will be possible to realize a device in which the above mentioned centering means are no longer used for maintaining drop 11 circular throughout its deformation, but in contrast for making the drop go from a rest position determined, for example, by the shape of the surface treatment 14, to an operating shape, determined, for example, by the outline of electrode 16. It is thus possible to create a variable focus cylindrical lens by using a surface treatment 14 of rectangular shape and centering electrodes 16 of rectangular outline.

It will be possible to apply the present invention to a device bridging more than one wall of chamber 12, drop 11 being placed, for example, in an angle or in a corner of chamber 12. According to this alternative, an electrode would of course be placed on the back surface of each wall in contact with drop 11, at the level of the contact region. Such an alternative would enable a variable deflection prism to be achieved.

As an example of conductor liquid 13, one may use water loaded with salts (mineral or other) or any other liquid, organic or not, which is conductive or made conductive by addition of ionic components. As an insulating liquid 11, one may use oil, an alcane or a blend of alcanes, eventually halogenated, or any other insulating liquid which is not miscible with conductor liquid 13. Chamber 12 may be comprised of a glass plate, treated with silane or covered with a thin coating of fluorinated polymer or of a sandwich of fluorinated polymer, epoxy resin, polyethylene.

Voltage V will preferably be alternating in order to avoid the accumulation of electric charges throughout material 12 from the surface on which drop 11 is placed.

In the exemplary embodiment of figure 1, drop 11 has a rest diameter of approximately 6 mm. The conductor liquid 13 and the insulating liquid of drop 11 being substantially of same density, drop 12 has a hemispheric shape. When it is at rest (position A), the edge of drop 11 is at an angle of

approximately 45° to the surface of chamber 12. In its limit position (position B), the edge of drop 11 is at an angle of approximately 90° to the surface of chamber 12. The described device, using as a conductor liquid 13 salt water of optical index 1.35 and, for the insulating liquid of drop 11, oil having an optical index of 1.45, achieves approximately 40 diopters of focus variation for an applied voltage of 250 volts and an electrical power of some mW. The frequency of the alternating voltage is in this case comprised between 50 and 10,000 Hz, its period being substantially smaller than the response time of the system which is several hundredths of a second.

The variable focus lens according to the present invention may have a size comprised between several tens of μm and several tens of mm, and may in particular be applied to the field of optoelectronic systems or to endoscopy.

CLAIMS

1. A variable focus lens comprising a chamber (12) filled with a first liquid (13), a drop of a second liquid (11) being disposed at rest on a region of a first surface of an insulating wall of the chamber, the first and second liquids being non miscible, of different optical indexes and of substantially same density, characterized in that:

the first liquid is conductive;

the second liquid is insulating;

in that it comprises:

means for applying a voltage between the conductor liquid and an electrode (16; 26; 35-37; 75-79) placed on the second surface of said wall; and

centering means for maintaining the centering of the edge of the drop while the voltage is applied and for controlling the shape thereof.

2. The variable focus lens according to claim 1, in which the centering means allows a continuous maintaining of the centering of the drop and a continuous control of the shape of the edge of the drop while a varying voltage is applied by said means for applying a voltage.

3. The variable focus lens according to claim 2, in which the first surface is substantially flat, the contact region (15) is circular and centered about an axis (O) which is perpendicular to the first surface.

4. The variable focus lens according to claim 3, in which the centering means corresponds to a progressive thickening of the second surface of the wall of the chamber towards said axis, said electrode (26) being applied against said second surface.

5. The variable focus lens according to claim 3, in which the centering means corresponds to a radial decrease of the wetting with respect to the first liquid (13), towards the center of said contact region (15) with the second liquid.

6. The variable focus lens according to claim 3, in which the centering means corresponds to a radial gradient of the dielectric constant of said wall of the chamber (53) at the level of said contact region (15) with the second liquid.

7. The variable focus lens according to claim 1, in which the first surface is substantially flat, the contact region (15) is circular and centered about an axis (O) perpendicular to the first surface, and wherein the centering means comprises an electrode formed of one or several circular concentric strips (35-37) insulated from each other, centered about said axis, the circular strips being supplied by distinct voltage sources of values decreasing towards said axis.

8. The variable focus lens according to claim 1, in which the chamber is cylindrical, the first surface is the internal surface of the chamber, the contact region with the second liquid corresponds to a cylindrical section of the chamber, the centering means is comprised of one or several cylindrical electrodes of same diameter, insulated from each other, placed side by side against the external surface of the chamber at the level of the border of said contact region, the electrodes being supplied by different voltages of values decreasing towards the center of said contact region.

9. The variable focus lens according to claim 1, in which the first surface is substantially flat, the contact region (15) is rectangular and symmetric with respect to an axis (O) perpendicular to the first surface and the centering means is comprised of an electrode formed of one or several rectangular concentric strips insulated from each other, symmetric with respect to said axis (O), the rectangular strips being supplied by distinct voltage sources of decreasing values towards said axis.

10. The variable focus lens according to claim 1, in which said wall is comprised of two non parallel planes and in which said region bridges said two planes.

VARIABLE FOCUS LENS

Abstract

A variable focus lens comprising a chamber (12) filled with a first liquid (13), a drop of a second liquid (11) being disposed at rest on a region of a first surface of an insulating wall of the chamber, the first and second liquids being non miscible, of different optical indexes and of substantially same density. The first liquid is conductive and the second liquid is insulating. The lens further comprises means for applying a voltage between the conductor liquid and an electrode (16) placed on the second surface of said wall; and centering means for maintaining the centering of the edge of the drop while the voltage is applied and for controlling the shape thereof.

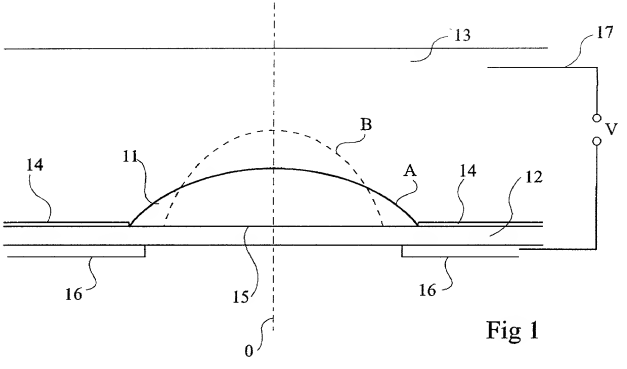

Fig 1

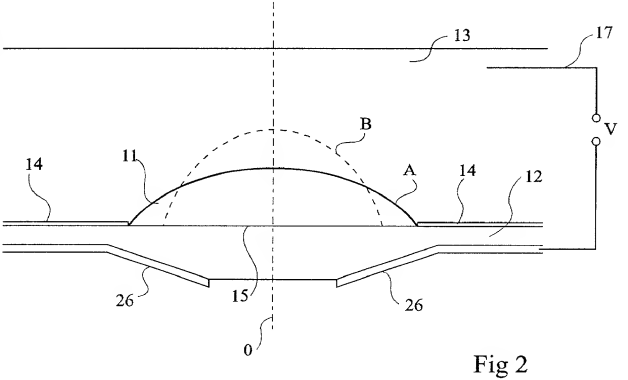

Fig 2

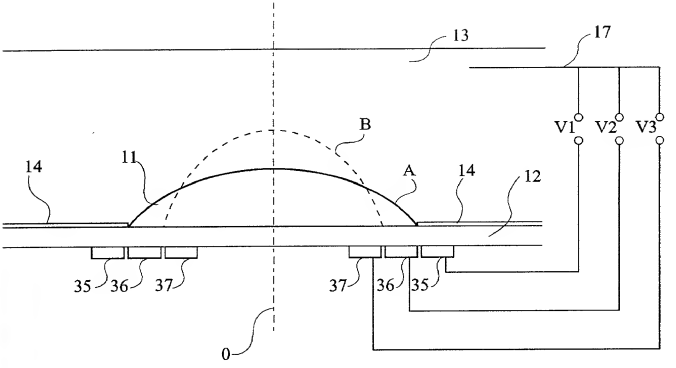

Fig 3

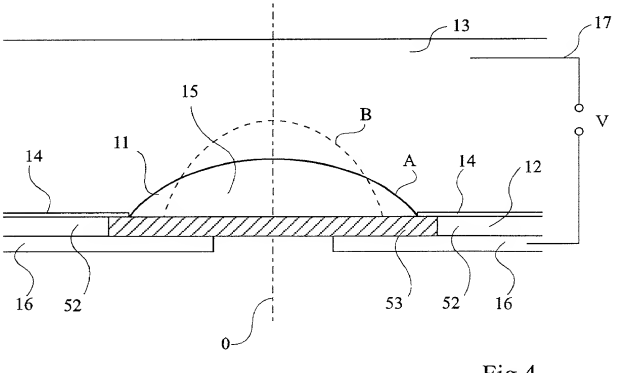

Fig 4

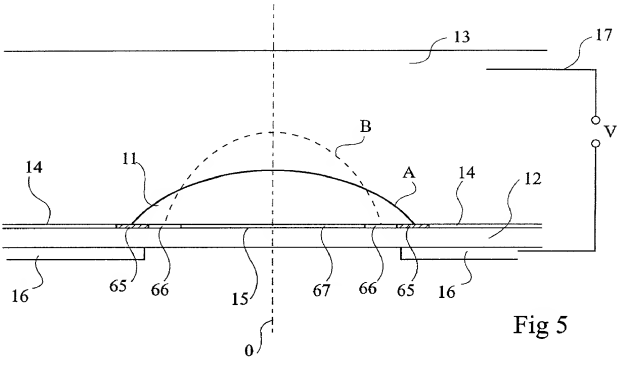

Fig 5

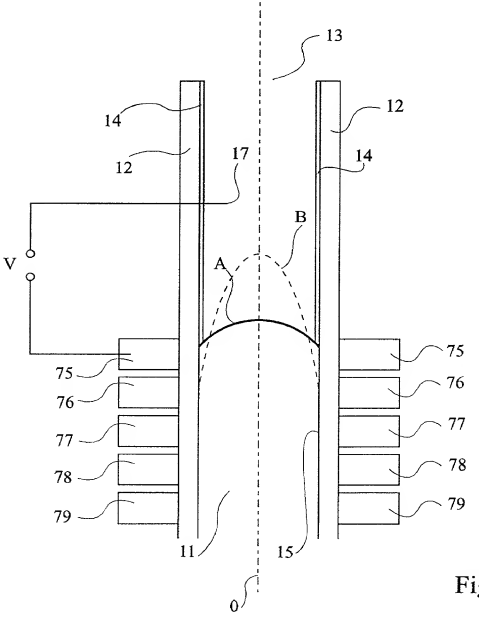

Fig 6

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	Berge-1
First Named Inventor	Berge
COMPLETE IF KNOWN	
Application Number	/ Herewith
Filing Date	Herewith
Group Art Unit	TBA
Examiner Name	TBA

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

VARIABLE FOCUS LENS

the specification of which *(Title of the Invention)*

☐ is attached hereto
OR
☒ was filed on (MM/DD/YYYY) 6 APRIL 2000 as United States Application Number or PCT International

Application Number 09/529 193 and was amended on (MM/DD/YYYY) _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
PCT/FR98/02143	PCT	10/7/98	☐	☐	☒
97/12781	FR	10/8/97	☐	☐	☒
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
		☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number [ ] → Place Customer Number Bar Code Label here
OR
☒ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number
Arthur L. Plevy	24,277	Jonathan M. Darcy	44,054
Edward J. Howard	42,670	Paul A. Schwarz	37,577
		Jane E. Alexander	36,014

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] OR ☒ Correspondence address below

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
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Inventor's Signature	Bruno BERGE					Date	4/24/2000
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Post Office Address							
City	LYON	State	69001	ZIP		Country	FR

☐ Additional inventors are being named on the ___ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

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DECLARATION

ADDITIONAL INVENTOR(S) Supplemental Sheet
Page 1 of 1

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor							
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Inventor's Signature							Date	
Residence: City		State		Country			Citizenship	
Post Office Address								
Post Office Address								
City		State		ZIP		Country		

Name of Additional Joint Inventor, if any:	☐ A petition has been filed for this unsigned inventor							
Given Name (first and middle [if any])			Family Name or Surname					
Inventor's Signature							Date	
Residence: City		State		Country			Citizenship	
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